【DOCUMENT NAME】 SPECIFICATION

【TITLE OF INVENTION】 HIGH-FREQUENCY CERAMIC PACKAGE

【SCOPE OF PATENT CLAIMS】

【Claim 1】 A high-frequency ceramic package, including a ring-shaped ceramic frame plate whose surface is brazed to a surface of a jointed metal plate, said jointed metal plate including first and second metal plates in which said first metal plate forms a substantially rectangular shape, said first metal plate having fixing holes defined at both ends in a longitudinal direction thereof and further having a hollowed portion formed at a central portion thereof, while said second metal plate is fitted in said hollowed portion of said first metal plate in a state in which said first and second metal plates are jointed together in an end-to-end relationship, thereby forming said jointed metal plate,
wherein one material that forms said first metal plate differs in thermal expansion coefficient from another material that forms said second metal plate; a cavity that is formed by a concave surrounded by said second metal plate and said ring-shaped ceramic frame plate has a semiconductor electronic component mounting portion on a bottom thereof; and said second metal plate is made from a material having an elevated degree of heat-sinking characteristics.

【Claim 2】 A high-frequency ceramic package as defined in claim 1, wherein said ring-shaped ceramic frame plate is brazed to said first and second metal plates in a state of being disposed across respective surfaces of said first and second metal plates along portion where said first and second metal plates are jointed

together.

【Claim 3】 A high-frequency ceramic package as defined in claim 1, wherein said ring-shaped ceramic frame plate is brazed to said first metal plate.

【Claim 4】 A high-frequency ceramic package as defined in claims 1 to 3, wherein said first metal plate is made from one of KV and a 42 alloy, both of which are close to ceramics in thermal expansion coefficient, said second metal plate is formed by a material having an elevated degree of heat-sinking characteristics, and said material is made from a compound material that includes copper and other metals.

【DETAILED DESCRIPTION OF DISCLOSURE】

【0001】

【FIELD OF INVENTION】

This invention relates to a high-frequency ceramic package. More particularly, it relates to a high-frequency ceramic package having a ring-shaped ceramic frame plate brazed to a jointed metal plate, the jointed metal plate including two kinds of metal plates jointed together.

【0002】

【PRIOR ART】

A prior art high-frequency ceramic package that is formed by a ring-shaped ceramic frame plate brazed to a metal plate is designed to protect electrical characteristics, in a high-frequency range of semiconductor electronic components.
More specifically, the semiconductor electronic components are disposed on a substantially rectangular-shaped metal plate that is made from highly heat-sinking material. Meanwhile, the

high-frequency ceramic package is formed by ceramics jointed to the metal plate. In this instance, one material that forms the ceramics is close in thermal expansion coefficient to another material that forms the metal plate. This structure avoids developing a curl in the ceramic package, and thus the semiconductor electronic components do not detract from their functions. FIGS. 4(A) and 4(B) illustrate a prior art high-frequency ceramic package 50. A ring-shaped ceramic frame plate 52 is bonded to a metal plate 51 through a metallized pattern by means of a silver/copper solder 54. The metal plate 51 is made from Cu-W (porous, copper-impregnated tungsten), which is close to ceramics in thermal expansion coefficient, and further which provides better heat-sinking characteristics. The metallized pattern is formed on the ring-shaped ceramic frame plate 52 on the reverse side thereof. In addition, leads 55 for connection to the outside are brazed to the ring-shaped ceramic frame plate 52 through a metallized pattern 53 by means of the silver/copper solder. The metallized pattern 53 is formed on the ring-shaped ceramic frame plate 52 on the obverse side thereof. The metal plate 51, the ring-shaped ceramic frame plate 52, and the leads 55 brazed together by means of the silver/copper solder are then nickel-plated and gold-plated on metal surfaces thereof, thereby forming the high-frequency ceramic package 50. The substantially rectangular-shaped metal plate 51 is provided with fixing holes 56 at both ends in a longitudinal direction thereof for fixing the ceramic package 50. The metal plate 51 is screwed down tight on a fixing member at the holes 56. In the ceramic package 50, the semiconductor electronic components are packaged

on the metal plate 51 at a position where the metal plate 51 is inside the ring-shaped ceramic frame plate 52. The packaged semiconductor components are then sealed in a hermetic sealing manner by means of resin.

【0003】

【TASK TO BE SOLVED BY INVENTION】

However, the prior art high-frequency ceramic package as previously described presents problems as given below:

(1) In a trend of the semiconductor electronic components toward higher frequencies, there has been an eager demand for a further heat-sinking level in order to avoid deteriorating electrical characteristics in a high-frequency range of the semiconductor electronic components. However, when a heat-sinking material made of a metal plate having an increased level of thermal conductivity and an elevated degree of heat-sinking characteristics is employed, a difference in thermal expansion coefficient between the metal plate and the ceramics produces an increased curl in the high-frequency ceramic package. As a result, there are cases where the semiconductor electronic components cannot be packaged on the metal plate.

(2) The increased curl in the ceramic package causes a distortion-caused bend in the ceramic package when the ceramic package is mounted on the fixing member. Such a bend brings about another problem in which the semiconductor electronic components on the metal plate are destroyed.

An object of the present invention is achieved in view of such situation, and aims to provide a high-frequency ceramic package, adapted for an additional heat-sinking level of such a ceramic

package and further for a decrease in the occurrence of a curl.

【0004】

【MEANS FOR SOLVING THE TASK】

A high-frequency ceramic package according to the present invention for attaining the above object includes a ring-shaped ceramic frame plate whose surface is brazed to a surface of a jointed metal plate, the jointed metal plate including first and second metal plates in which the first metal plate forms a substantially rectangular shape, the first metal plate having fixing holes defined at both ends in a longitudinal direction thereof and further having a hollowed portion formed at a central portion thereof, while the second metal plate is fitted in the hollowed portion of the first metal plate in a state in which the first and second metal plates are jointed together in an end-to-end relationship, thereby forming the jointed metal plate, wherein one material that forms the first metal plate differs in thermal expansion coefficient from another material that forms the second metal plate; a cavity that is formed by a concave surrounded by the second metal plate and the ring-shaped ceramic frame plate has a semiconductor electronic component mounting portion on a bottom thereof; and the second metal plate is made from a material having an elevated degree of heat-sinking characteristics. Since the first metal plate can be made from a material close to ceramics in thermal expansion coefficient, the jointed metal plate provides a reduced curl, even when the ring-shaped ceramic frame plate is jointed to the first metal plate, and in addition, since the second metal plate, which forms a portion where the semiconductor electronic components are

disposed, can be made of a highly heat-sinking metal plate that has a high degree of thermal conductivity, the high-frequency ceramic package according to the present invention is allowed to provide a high level of cooling effects, and thus to maintain electrical characteristics under the circumstances in which the semiconductor electronic components have higher frequencies prevail.

【0005】

The ring-shaped ceramic frame plate may be brazed to the first and second metal plates in a state of being disposed across respective surfaces of the first and second metal plates along a position where the first and second metal plates are jointed together. Consequently, even when one of the first and second metal plates differs from the ring-shaped ceramic frame plate in thermal expansion coefficient, then the other of the first and second metal plates can be made from a material close to the ring-shaped ceramic frame plate in thermal expansion coefficient in order to mitigate the occurrence of the curl. As a result, a reduced curl occurs in the jointed metal plate. Moreover, since the ring-shaped ceramic frame plate is brazed across the respective surfaces of the first and second metal plates, the first and second metal plates can be jointed together with increased strength and hermetic sealing. As an alternative, the ring-shaped ceramic frame plate may be brazed to the first metal plate. In this instance, the first metal plate is made from a material close to the ring-shaped ceramic frame plate in thermal expansion coefficient. As a result, a curl in the jointed metal plate is reduced. Further, the first metal plate may be made from

either KV or a 42 alloy, both of which are close to ceramics in thermal expansion coefficient, while the second metal plate may be formed by a highly heat-sinking material that is made from a compound material including copper and other metals. As a result, even when the ring-shaped ceramic frame plate is brazed to such a jointed metal plate, a curl can be restrained from occurring in the jointed metal plate. Furthermore, the above-described jointed metal plate structure is able to ensure a heat-sinking material adapted to accommodate high heat radiation from the semiconductor electronic components.

【0006】

【BEST MODE FOR CARRYING OUT INVENTION】

Next, the mode for carrying out the present invention will be described referring the accompanying drawings in order to have the present invention understood.

FIG. 1 is a perspective view of a high-frequency ceramic package according to an embodiment of the present invention;

FIG. 2(A) and 2(B) are a front view and a cross-sectional view of a jointed metal plate of the high-frequency ceramic package respectively; and

FIG. 3(A) and 3(B) are enlarged partial cross-sectional views of a jointed portion of first and second metal plates and a ring-shaped ceramic frame plate of the high-frequency ceramic package respectively.

【0007】

An initial description will now be made of how a high-frequency ceramic package 10 according to an embodiment of the present invention is constructed. FIG. 1 illustrates a ring-shaped

ceramic frame plate 12 brazed to a jointed metal plate 11 through metallized patterns formed on the reverse side of the ring-shaped ceramic frame plate 12 by means of, e.g., a silver/copper solder. In addition, leads 13 for connection to the outside are brazed to the ring-shaped ceramic frame plate 12 through metallized patterns 14 by means of, e.g., the sliver/copper solder. The metallized patterns 14 are formed on the ceramic frame plate 12 on the obverse side thereof. The lead 13 is formed by either KV (Koval) or a 42-alloy. Then, the jointed metal plate 11, the ring-shaped ceramic frame plate 12, and the leads 13 are nickel-plated and gold-plated on metal surfaces thereof after being soldered, thereby forming the ceramic package 10. The substantially rectangular-shaped jointed metal plate 11 is provided with fixing holes 15 at both ends of the jointed metal plate 11 in a longitudinal direction thereof for fixing the ceramic package 10. The jointed metal plate 11 is screwed down tight on an outside fixing member at the fixing holes 15. In the ceramic package 10, semiconductor electronic components are packaged in a cavity 16 on a bottom 16a thereof. The cavity 16 is comprised of a concave formed by the jointed metal plate 11 and the ring-shaped ceramic frame plate 12. The packaged semiconductor components are then hermetically sealed by means of resin. A metal material that forms the bottom 16a of the jointed metal plate 11 is made from a highly heat-sinking material having a high level of thermal conductivity. Such a heat-sinking material includes, e.g., Cu-W (copper-soaked tungsten) and CMC (a jointed plate having three layers of Cu-Mo-Cu). Meanwhile, a low thermal expansion material close to ceramics in thermal

expansion coefficient, such as KV and the 42-alloy, forms a peripherally extending metal portion around the bottom 16a, which supports the bottom 16a.

【0008】

Then, a structure of the jointed metal plate 11 will now be described. As illustrated in FIGS. 2(A) and 2(B), the jointed metal plate 11 which forms a substantially rectangular shape has the holes 15 formed at both ends of the plate 17 in the longitudinal direction thereof, and further has a hollowed portion 19 defined at a central portion of the first metal plate 17. The second metal plate 18 is fitted in the hollowed portion 19 of this first metal plate 17, while the hollowed portion 19 has end surfaces brazed to outer peripheral end surfaces of the second metal plate 18 by means of, e.g., a silver/copper solder 20. The first and second metal plates 17, 18 are made from metal materials that differ from one another in both thermal expansion coefficient and thermal conductivity, and the first metal plate 17 is fabricated from a low thermal expansion material. The ring-shaped ceramic frame plate 12 surrounds the cavity 16. The second plate 18 forms the bottom 16a of the cavity 16, on which the semiconductor electronic components are disposed. The second metal plate 18 is formed by a metal material having a high degree of heat-sinking characteristics. Such a metal structure is able to meet a demand for a high level of heat sinking, which is created in response to a trend of the semiconductor electronic components toward higher frequencies, and thus to maintain high-frequency characteristics.

【0009】

A further description will be given of how the ring-shaped ceramic plate 12 is jointed to the jointed metal plate 11 that includes the first and second metal plates 17, 18 referring FIGS. 3(A) and 3(B). The ring-shaped ceramic frame plate 12 is preferably brazed to the first and second metal plates 17, 18 by means of, e.g., a silver/copper solder 21 in a state in which the ring-shaped ceramic plate 12 extends along a position where the first and second metal plates 17, 18 are jointed together, and further which the ceramic plate 12 is disposed across respective surfaces of the first and second metals 17, 18 so as to cover the position where the metal plates 17, 18 are jointed together (Refer to FIG. 3(A)). At this time, the ring-shaped ceramic plate 12 may be brazed by means of the silver/copper solder 21 after the first and second metal plates 17, 18 are jointed together by means of the silver/copper solder 20. Alternatively, the first and second metal plates 17, 18 and the ring-shaped ceramic plate 12 are jointed together at one time by means of the solders 20, 21. The ring-shaped ceramic plate 12 thus bonded to the metal plates 17, 18 across the respective surfaces thereof through the solder 21 provides good bonding between the metal plates 17, 18 and enhanced hermetic sealing reliability, even when the solder 20 is deficient in structural bond integrity between the metal plates 17, 18. Furthermore, efficient brazing is realized by simultaneous bonding of the metal plates 17, 18 and the ring-shaped ceramic plate 12 together through the solders 20, 21.

【0010】

The ring-shaped ceramic plate 12 may be jointed to the first metal plate 17 through the silver/copper solder 21 (Refer to FIG. 3(B)).

This structure is possible to restrain the occurrence of a curl even when the ring-shaped ceramic frame plate 12 is brazed by means of the silver/copper solder 21, which otherwise would be caused by a difference in thermal expansion coefficient, because the first metal plate 17 is close to ceramics in thermal expansion coefficient. The ring-shaped ceramic plate 12 may be brazed to the first metal plate 17 by means of the solder 21 after the first and second metal plates 17, 18 are initially jointed together by means of the solder 20. Alternatively, the ring-shaped ceramic plate 12 may be jointed to the first metal plate 17 through the solder 21, while the first and second metal plates 17, 18 are jointed together through the solder 20. Furthermore, efficient brazing is achievable when the metal plates 17, 18 and the ring-shaped ceramic plate 12 are jointed together at one time through the solders 20, 21.

【0011】

Since the ring-shaped ceramic plate 12 is jointed to the first metal plate 17, it is preferable that the first plate 17 is close to ceramics in thermal expansion coefficient. Thus, KV and the 42-alloy, both of which are low in cost, are suitable as a material of the first metal plate 17. In this connection, alumina (Al_2O_3) has a thermal expansion coefficient of 6.7×10^{-6} /K, while KV has that of 5.3×10^{-6} /K. In order to maintain electrical characteristics under the circumstances in which the semiconductor electronic components have higher frequencies prevail, the second metal plate 18 must highly be operative to abate heat that radiates from the semiconductor electronic components. This means that the second metal plate 18 is required

to provide a high level of heat-sinking ability, and thus to enhance cooling effectiveness. Thus, it is wise to use a compound material in which a highly heat-sinking material or copper is based. For example, the second metal plate 18 is preferably made of a CMC substrate having three layers of Cu-Mo-Cu jointed together at a thickness ratio of 1:1:1. In this connection, CMC has thermal conductivity of 260W/m·K, while Cu-W has that of nearly 230W/m·K.

【0012】

The ring-shaped ceramic frame plate 12 is formed by the steps of: adding a plasticizer such as dioxyl phthalate, a binder such as acrylic resin, and a solvent such as toluene, xylene, and alcohol to powder in which a sintering assistant such as magnesia (MgO), silica (SiO_2), and calsia (CaO) is added in a proper amount to alumina powder; fully kneading the above materials, thereby creating a slurry having a viscosity that ranges from 2000 to 40000 cps after defoaming of the kneaded powder; forming the slurry into a roll-like ceramic green sheet by means of a doctor blade process; cutting the ceramic green sheet into rectangular pieces, each of which has an appropriate size; screen-printing a metallized pattern on the ceramic green sheet, in which the metallized pattern is made from a metal having a high melting point, such as tungsten; punching the ceramic green sheet to a ring-like shape; and firing the sheet in a reducing atmosphere of a some 1550 ℃. In order to provide the ring-shaped ceramic frame plate 12 having a required height, the ceramic green sheet is sometimes formed by a plurality of ceramic green sheets being laminated. In this connection, ceramic is not limited to certain

types, and ceramics such as, e.g., alumina, aluminum nitride, and lower temperature fired glass ceramics are usable.

【0013】

【EMBODIMENT】

The Inventor compared the high-frequency ceramic package according to an embodiment of the present invention with comparison examples in order to evaluate a thermal resistance value, the occurrence of a curl, and cost. The thermal resistance value exhibits heat-sinking characteristics of a jointed metal plate (metal plate for the comparison examples), and decreases with an increase in heat sinking. A ring-shaped ceramic frame plate bonded to the jointed metal plate (metal plate) by means of a silver/copper solder was a 10 mm wide, 22 mm long, and 1.0 mm thick rectangular frame of alumina ceramics, which was perforated as the form of a ring having a width of 1.2 mm. The metal plate was 10 mm wide, 34 mm long, and 1.6 mm thick, and in an embodiment of the present invention, first and second metal plates were made from KV and CMC, respectively. The second metal plate was a jointed plate having three layers of copper-molybdenum-copper. In comparison examples, two different kinds of metal plates were used, but each of them was made from a single material. More specifically, one metal plate was fabricated from porous, copper-impregnated tungsten or Cu-W (10% copper), while the other was made from CMC (having a thickness ratio of CU, Mo, and Cu = 1:1:1). A curl was measured by a tracer method-based surface roughness meter being moved on the reverse side of the metal plate along a diagonal thereof.

【0014】

【TABLE 1】

	Embodiment	Comparison examples	
	KV+CMC	Cu-W	CMC
Thermal resistance	0.7	1	0.7
Curl (μm)	10 to 20	-10 to 10	30 to 60
Cost	0.5	1	0.9

Note 1: For Cu-W, thermal resistance and cost are valued at 1.0.

Note 2: the above positive values of the curl represent a situation in which the metal plate is rendered convex toward the ring-shaped ceramic frame plate bonded to the metal plate.

【0015】

As the result of the comparison and seen from Table 1, the jointed metal plate in the high-frequency ceramic package according to the present invention exhibits a smaller thermal resistance value with reference to 1.0 of a Cu-W thermal resistance value in the comparison example. More specifically, it amounts to 70% of the Cu-W thermal resistance value in the comparison example. Consequently, the ceramic package according to the present invention is possible to ensure a high level of heat-sinking ability. The jointed metal plate according to the present invention produces a curl somewhat greater in positive value than a Cu-W curl in the comparison example. In other word, the jointed metal plate according to the present invention has the curl made convex toward the ceramic frame plate to a greater degree than the Cu-W curl in the comparison example. However, such a greater curl is of insignificant importance in view of availability of the high-frequency ceramic package according to the present

invention. In addition, although there are variations in the curl of the jointed metal plate according to the present invention, the degree of such curl variations is smaller than that of CMC curl variations in the comparison example. Furthermore, the jointed metal plate according to the present invention costs a half of Cu-W in the comparison example with respect to 1.0 of a Cu-W cost value, and further costs less than CMC in the comparison example.

【0016】

【EFFECT OF INVENTION】

In the high-frequency ceramic package according to Claims 1 to 4, the material that forms the first metal plate differs in thermal expansion coefficient from another material that forms the second metal plate, the cavity that is formed by the concave surrounded by the second metal plate and the ring-shaped ceramic fame plate has a semiconductor electronic component mounting portion on the bottom of the cavity, and the second metal plate is made from a material having an elevated degree of heat-sinking characteristics. Thereby, the metal plate provides a reduced curl, even when the ring-shaped ceramic frame plate is jointed, and in addition, since the semiconductor electronic component mounting portion can be made of a highly heat-sinking metal plate, it becomes possible to deal with a trend of the semiconductor electronic components toward higher frequencies.

【0017】

Especially in the high-frequency ceramic package according to Claim 2, since the ring-shaped ceramic frame plate is brazed to the first and second metal plates in a state of being disposed

across respective surfaces of the first and second metal plates along a position where the first and second metal plates are jointed together. Consequently, even when one of the first and second metal plates differs from the ring-shaped ceramic plate in thermal expansion coefficient, then the other of the first and second metal plates mitigate the occurrence of a curl, thereby the curl of the jointed metal plate can be reduced. Furthermore, since the ring-shaped ceramic frame plate is brazed across the respective surfaces of the first and second metal plates, the first and second metal plates can be jointed together with increased strength and hermetic sealing.

【0018】

Further, in the high-frequency ceramic package according to Claim 3, since the ring-shaped ceramic frame plate is brazed to the first metal plate, a material that is close to the ring-shaped frame plate in thermal expansion coefficient can be chosen for the first metal plate, thereby a curl in the jointed metal plate can be reduced.

【0019】

Still further, in the high-frequency ceramic package according to Claim 4, since the first metal plate is made from either KV or a 42 alloy, both of which are close to ceramics in thermal expansion coefficient, and the second metal plate is formed by a highly heat-sinking material that is made from a compound material including copper and other metals, a curl in the jointed metal plate can be restrained even when the ring-shaped ceramic frame plate is brazed, and moreover, a heat-sinking material adapted to accommodate high heat radiation from the semiconductor

electronic components can be ensured.

【BRIEF EXPLANATION OF DRAWINGS】

【FIG. 1】

A perspective view of a high-frequency ceramic package according to an embodiment of the present invention.

【FIG. 2】

(A) and (B) are a front view and a cross-sectional view of a jointed metal plate of the high-frequency ceramic package respectively.

【FIG. 3】

(A) and (B) are enlarged partial cross-sectional views of a jointed portion of first and second metal plates and a ring-shaped ceramic frame plate of the high-frequency ceramic package respectively.

【FIG. 4】

(A) and (B) are a plane view and a front view of a conventional high-frequency ceramic package respectively.

【EXPLANATION OF SYMBOLS】

10: high-frequency ceramic package, 11: jointed metal plate, 12: ring-shaped ceramic frame plate, 13: metallized pattern, 14: lead, 15: fixing hole, 16: cavity, 16a: bottom, 17: first metal plate, 18: second metal plate, 19: hollowed portion, 20, 21: silver/copper solder